

Giant supercooling in patterned FeRh nanodisk arrays

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Supercooling, where a high-temperature phase persists far below its transition temperature, is typically limited to less than 18% of T_m [1]. Here we demonstrate exceptionally deep supercooling exceeding 150 K in disk arrays patterned from FeRh thin films, which exhibit a first-order magnetostructural transition between antiferromagnetic (AF) and ferromagnetic (FM) phases near 370 K. This transition is appealing as it involves large changes in lattice parameter, entropy, and electrical resistivity, making FeRh a model system for both fundamental studies and applications such as magnetocalorics, spintronics, heat-assisted magnetic recording, and sensing [2].

We pattern epitaxial FeRh thin films into arrays of nanodisks (200–700 nm diameter) and study their transition behavior using magnetic force microscopy under applied magnetic fields. While micron-sized disks transition gradually via continuous AF domain nucleation, submicron disks exhibit abrupt transitions without phase coexistence at significantly lower temperatures than that of the original thin film. The fraction of deeply supercooled disks strongly increases as disk size decreases. Classical nucleation theory is used to estimate the size- and temperature-dependent energy barriers between metastable FM and stable AF states. We discuss that strain and thermal history have the greatest impact on the occurrence of supercooling.

References:

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[2] L. H. Lewis, C. H. Marrows, and S. Langridge, *Journal of Physics D: Applied Physics* 49 (2016) 323002